

NATIONAL MANUFACTURING STRATEGY

Is a National Manufacturing Strategy Essential to National Security?

BY

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USAWC CIVILIAN RESEARCH PROJECT

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ABSTRACT

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NATIONAL MANUFACTURING STRATEGY

Is a National Manufacturing Strategy Essential to National Security?

“A free people ought not only to be Armed, but disciplined; to which end a uniform and well-digested plan is requisite; and their safety and interest require that they should promote such manufactories as tend to render them independent of others for essentials, particularly military supplies.”¹

George Washington
Speech to Congress January 8, 1790

“But, ah, think what you do when you run a debt; you give to another power over your liberty. If you cannot pay at the Time, you will be ashamed to see your Creditor; you will be in Fear when you speak to him; you will make poor pitiful sneaking Excuses, and by Degrees come to lose your Veracity, and sink into base down-right lying; for as Poor Richard says, The Second Vice is Lying, the first is running in Debt.”²

Benjamin Franklin
Poor Richards Almanac 1758

Historically manufacturing was a foundational element of national power. The responsive agility and capacity of the U.S. defense industrial base holds vaunted historical distinction for being critically decisive in the outcome of World War II. In military strategic parlance, it was our center of gravity as Japanese Admiral Yamamoto infamously recognized after attacking Pearl Harbor and allegedly declaring, “I fear all we have done is to awaken a sleeping giant.”³ The contribution of manufacturing in our ascendancy as a world economic super power is no less recognized and equally chronicled as fundamental to the critical path to our unrivaled wealth and prosperity.

In the 2010 annual Industrial Capabilities report to Congress required by U.S. Code, the Department of Defense states it will “rely on market forces to create, shape and sustain the industrial, manufacturing, and technological capabilities to provide our fighting forces with systems that can engage and win full-spectrum warfare. However, when absolutely necessary

the Department will intervene to create and/or sustain competition, innovation, and essential industrial capabilities.”⁴ This paper looks at this methodology and questions if the nation’s manufacturing industry has eroded to the point of constituting a threat to national security that requires decisive intervention through a coordinated national manufacturing strategy.

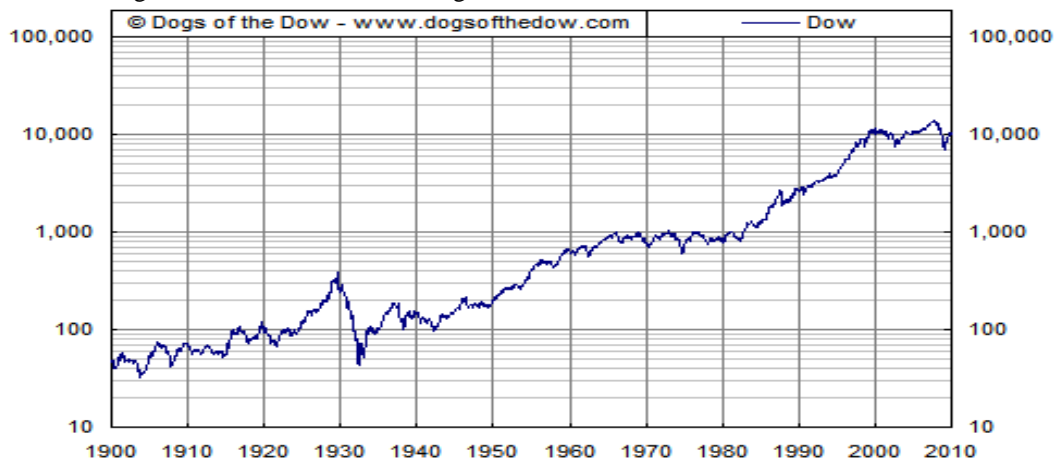
Over the last several decades, U.S. markets saw tremendous expansion in the financial and service industries. At the same time, manufacturing contracted with sharp declines in the production of goods, both for export and domestic use. Demand for goods, however, grew unabated and in the case of some products, like electronics, nearly exponentially to the point of synthesizing an economy based on a voracious consumer appetite and easy freewheeling credit.

Anecdotally, the most well known market index demonstrates the transformation of the U.S. economy. Dow Jones created the Industrial Average to gauge the performance of the traditionally all-important heavy industrial sector and thereby serve as the key indicator of the U.S. economy. The “industrial” tag is now little more than a historical reference since two thirds of the 30 companies that make up the index today do not manufacture any durable goods at all.⁵ Table 1 below shows the companies and market sector of the companies that make up the current Dow Jones Industrial Average. Figure 1 is a logarithmic scale of the index from 1900 through 2010.

Table 1. Companies that make up Dow Jones Industrial Average.

| <u>Symbol</u> | <u>Company</u> | <u>Sector</u> | <u>Industry</u> |
|---------------|----------------------------------|-----------------------|--------------------------------------|
| <u>DD</u> | DuPont | Basic Materials | Chemicals |
| <u>AA</u> | Alcoa | Basic Materials | Metal Mining |
| <u>BA</u> | Boeing | Capital Goods | Aerospace & Defense |
| <u>CAT</u> | Caterpillar | Capital Goods | Construction & Agriculture Machinery |
| <u>GE</u> | General Electric | Conglomerates | Conglomerates |
| <u>MMM</u> | Minnesota Mining & Manufacturing | Conglomerates | Conglomerates |
| <u>UTX</u> | United Technologies | Conglomerates | Conglomerates |
| <u>KFT</u> | Kraft | Consumer/Non-Cyclical | Food - Major Diversified |
| <u>KO</u> | Coca-Cola | Consumer/Non-Cyclical | Beverages (Non-Alcoholic) |
| <u>PG</u> | Procter & Gamble | Consumer/Non-Cyclical | Personal & Household Products |
| <u>CVX</u> | Chevron | Energy | Oil & Gas – Integrated |
| <u>XOM</u> | ExxonMobil | Energy | Oil & Gas – Integrated |
| <u>BAC</u> | Bank of America | Financial | Money Center Banks |
| <u>JPM</u> | JP Morgan Chase | Financial | Money Center Banks |
| <u>AXP</u> | American Express | Financial | Consumer Financial Services |
| <u>TRV</u> | The Travelers Companies | Financial | Property & Casualty Insurance |
| <u>PFE</u> | Pfizer | Health Care | Major Drugs |
| <u>MRK</u> | Merck | Healthcare | Major Drugs |
| <u>JNJ</u> | Johnson & Johnson | Healthcare | Major Drugs |
| <u>VZ</u> | Verizon | Services | Communications Services |
| <u>HD</u> | Home Depot | Services | Retail (Home Improvement) |
| <u>MCD</u> | McDonald's | Services | Restaurants |
| <u>WMT</u> | Wal-Mart | Services | Retail (Department & Discount) |
| <u>DIS</u> | Disney | Services | Broadcasting |
| <u>T</u> | AT&T | Technology | Communications Services |
| <u>INTC</u> | Intel | Technology | Semiconductors |
| <u>MSFT</u> | Microsoft | Technology | Software & Programming |
| <u>IBM</u> | International Business Machines | Technology | Computer Hardware |
| <u>HPQ</u> | Hewlett-Packard | Technology | Computer Hardware |
| <u>CSCO</u> | Cisco Systems | Technology | Networking & Communication Devices |

Figure 1. Dow Industrial Average from 1900



The suitability and sustainability of a conversion to a financial, service and consumer based economy at the expense of manufacturing and a valued product based economy was always suspect for many. Recurring boom and bust cycles and recent economic trends bring increasing scrutiny of these sectors as valid substitutes for undergirding any economy, let alone a world super power. Due to the severity of the economic stress, the magnitude of lost wealth and similarities, it is worthwhile to review a couple of the recent busts, namely the dot-com and housing market bubbles.

After unprecedented economic performance throughout the 1980s and 1990s, an economy heated by the proliferation of Dot-coms continued to accelerate into the new millennium despite repeated attempts by the Fed to slow it through interest rate hikes. The DOW reached a new peak on January 14, 2000 and Super Bowl XXXIV, played on January 30, 2000 featured 17 Dot-com advertisements at the rate of two million dollars for a 30-second advertisement spot.⁶ During this period, “day traders” became a household term coined for the thousands of people who left their jobs to earn livings trading stocks from home, but tens of thousands more were day trading on the side.

The dot-com bubble reached a peak on Friday March 10, 2000, with the technology-tracking NASDAQ index having doubled over the previous calendar year.⁷ The initial bursting drop was just as precipitous, with the NASDAQ losing more than 10% in the next 10 days and exposing the first weaknesses in the over-hyped get rich internet e-schemes. With the economy already in free fall, the attack of 9-11 delivered another financial shockwave. When the dust settled, there was a greater than 30% loss in total market value of United States companies

between March 2000 and October 2002, with an accompanying 78.4% drop in the NASDAQ and the erasure of over \$8 trillion dollars.⁸

In 2006, the markets recovered back to 2000 levels before setting off on another sharp rise that peaked in the fall of 2007 before being devastated by the next bubble when home prices began falling. Low initial adjustable rate credit terms, coupled with relaxed lending standards created a home buying frenzy and borrowers took on unprecedented levels of debt and risk. The acceleration in demand for new homes drove up the cost of building materials and home values increased accordingly. This spawned further investment speculation in real estate and increased the money supply through home equity credit lines, which often went back into property and helped create a self-sustaining cyclic system.

The market hemorrhaged when home prices began to fall and fixed term loans had ratcheted up to unfavorable rates before the low initial adjustable rate terms expired. Upside down on their loans, borrowers began defaulting at unprecedented rates. Further exposure of poor practices and lack of oversight in the subprime mortgage market led to insecurities and the tightening of global credit and treasury markets. Foreclosure proceedings grew by 79% in 2007, another 81% in 2008 and 21% in 2009.^{9 10} By 2010, this vicious cycle found nearly a quarter of all homeowners owning more than their home was worth.¹¹

Both Paul Volcker and Warren Buffet arrived at similar conclusions in outlining some of the flawed assumptions that led to these crises. One of the fallacies was that “economic imbalances, such as large trade deficits, and low savings rates, indicative of over consumption, were sustainable...”¹²

The decline in manufacturing started even before the boom and bust cycles of synthesized economies on financed consumerism. In the era of globalization and free trade, the

outsourcing and off shoring of manufacturing promised substantial benefit to the bottom line. In essence, America accepted the notion that we no longer needed an industrial base, if not consciously in ideology, certainly in practice of the cultural business imperative, the pursuit of profits. Within a culture and Federal Reserve fixated on corporate profit, there appeared little regulatory concern, or reason for public attention, for safeguarding industry as the foundation or at least one of the pillars of the economy during the boom markets of the 1990s. Regulatory practices akin to isolationism and protectionism were an anathema to the promise of profits accepted prima facie as an article of faith from globalization and free market enterprise.

U.S. manufacturing has not recovered any ground since the recession of 2001, which coincided with China entering the World Trade Organization. From 2001 through 2009, average sector losses exceeded 50,000 jobs per month since.¹³ During the same period, 42,000 manufacturing plants closed, including the evaporation of 36% of all plants employing over 1000 people and 38% of those employing between 500-1000 people.¹⁴ A report titled *Manufacturing Insecurity: America's Manufacturing Crises and the Erosion of the U.S. Industrial Base* prepared by Joel S. Yudken, Ph.D. for the Industrial Union Council of the AFL CIO shows the loss of

manufacturing plants by employment, comparing the period 1990 - 1998 to 1998 - 2008, shown in Figure 2.

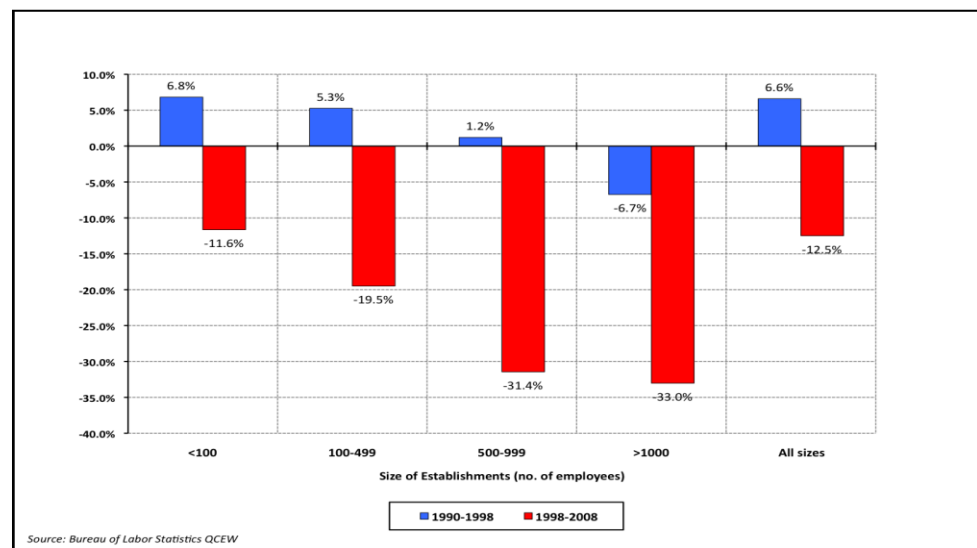


Figure 2: Manufacturing Plant Gains and Losses by Number of Employees.

By the end of 2009, the manufacturing sector bled out over 32% of its jobs, over 5.7 million jobs in total, and for the first time ever, fewer people were employed in the manufacturing sector since prior to the build up for World War II in 1941.¹⁵ A graph of historical manufacturing employment since 1940 is in

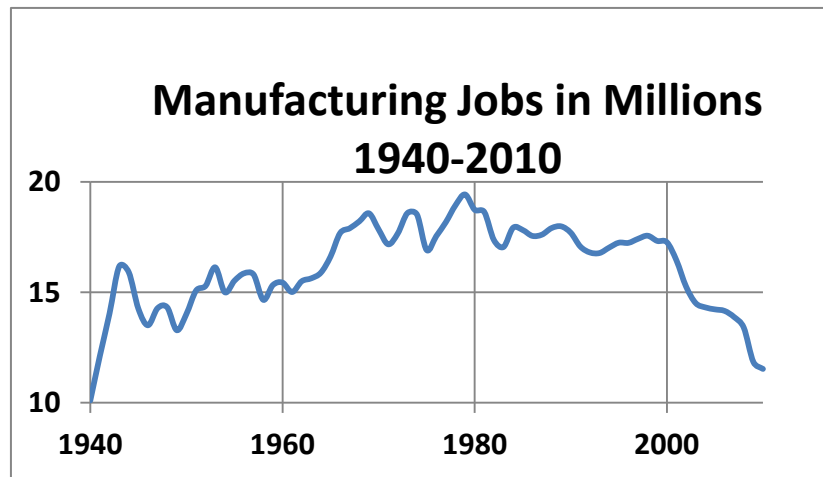


Figure 3.

Figure 3: Manufacturing Job Losses, Bureau of Labor Statistics.

There is now widespread recognition of the fallacy and danger of such deep losses in manufacturing. Our out of control debt crises highlights the obvious. It is hard to escape the conclusion that without manufacturing our trade deficits will continue to skyrocket.

In summarizing the damage, Jeff Faux, the founding president and distinguished fellow of the Economic Policy Institute opined, "we have allowed our industrial base to deteriorate for the last two to three decades. As a result, just in national defense terms, our supply lines for strategic parts and materials have been stretched around the world"¹⁶ and Robert Baugh, executive director of the AFL-CIO, said "As you watch globalization move the manufacturing base offshore, in essence you are moving the defense base offshore. This is dangerous."¹⁷ Recently the Chairman of the Joint Chiefs of Staff, Admiral Mullen, identified the national debt as the greatest threat to our national security.¹⁸

Concealed within the devastation of U.S. manufacturing there are uncalculated losses to critical defense industries and infrastructure. It is a common observation that globalization and outsourcing have extended supply lines for strategic components and materials around the world.

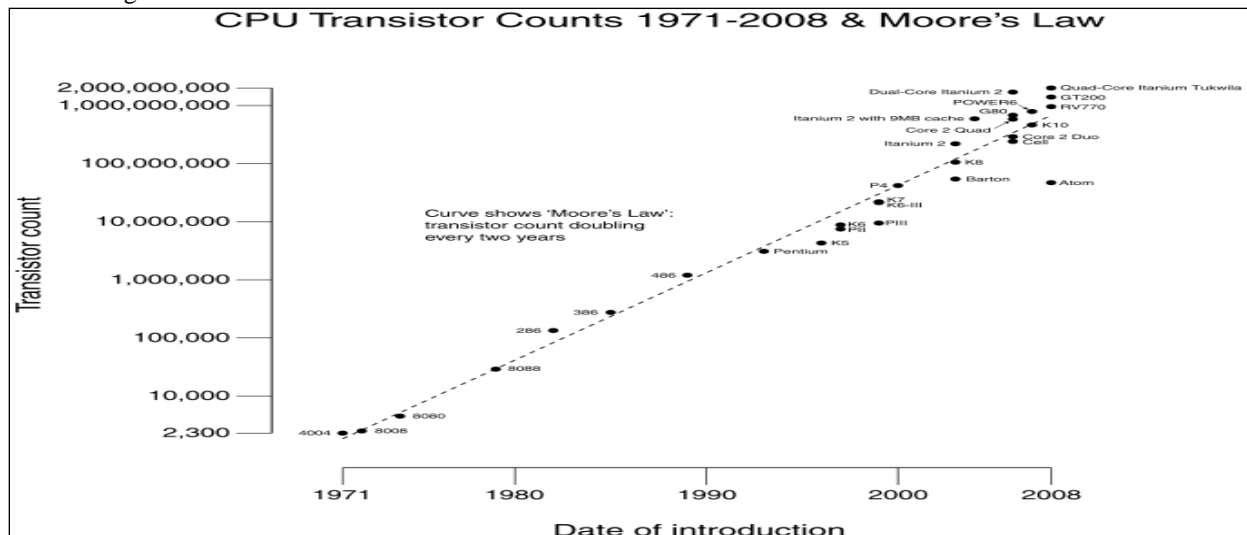
This is equally true for critical defense weapons systems subcomponents and especially true of electronics. The capability advances garnered through microelectronics arguably constitute the foundation of our strategic technological military advantage, and their production is increasingly becoming almost exclusively dependent on overseas manufacturing.

Case Study: Semiconductor Wafer Industry. The history of the semiconductor industry is an instructive account. It begins with exceptional American ingenuity and subsequent rapid transition through innovative manufacturing to the establishment and dominance of a new world changing global market. It is a story of phenomenal industrial productivity followed by the now too familiar pattern of the promulgation of intellectual property, market consolidation, outsourcing, global competition and eventually and most importantly America's decline in the market. It is also one of an insidious loss of manufacturing capacity of strategic significance to the national defense industrial base.

Silicon wafers are the fundamental building blocks upon which the integrated circuits of silicon chips are constructed. Silicon chips constitute the vast majority of all microelectronics, though some smart chips use germanium or other more exotic semiconductor materials. However, the story remains the same. The invention of the integrated circuit in 1958 revolutionized the electronics industry with a way to miniaturize electrical circuit components and integrate them onto a single chip smaller than a dime. Significantly, the scientific process was adaptable to manufacturing automation. Although, the original chips only contained a singular integrated circuit, the leaps forward came in the capacity to multiply the number of imbedded circuits. This led to the formation of Moore's law. In 1965, Moore showed that the number of integrated circuits built on silicon chip was doubling every year and projected this trend could last another 10 years. In 1975, he adjusted his prediction to doubling every two

years and this prediction remains accurate even today. This led to a continuum of revolutionary technological advances that even Moore could not foresee. The number of integrated circuits built on a single CPU chip exceeded one million in 1989, and one billion in 2005.¹⁹ Figure 4 shows Moore's law prediction line and actual transistor counts milestones on a logarithmic scale.

Figure 4. Moore's Law



The increased performance of electronic devices is proportional to this exponential rate of increasing the number of integrated circuits on a chip. Put another way, technical advances are possible through the science of miniaturization or the new field of “nanotechnology.” While the size of the silicon chip remained essentially constant, the circuits increased exponentially and the electronic features within the silicon have necessarily shrunk proportionally. Line width, the distance between the transistors on a silicon chip, reveals this progress. In 1990, a state of the art chip line width was 800 nanometers, by the year 2000 it was down to 180 nanometers and now in 2010 it is down to 45 nanometers. For comparison, the thickness of a human hair is about 60,000 nanometers.²⁰ Physically, 45 nanometers of separation is a mere 83 layers of silicon atoms between any of the now billions of transistors found within a silicon chip. These rapid improvements in technology created an intense demand for the latest and greatest and the

phenomenon of rapid obsolescence soon followed. Similar to the situation in the housing market, the situation reversed with insatiable expectations for new capabilities spurring on new products.

In an American example of manufacturing excellence, hardly a year after the invention of the integrated circuit, Monsanto jump-started the silicon wafer manufacturing industry in 1959. In forming Monsanto Electronic Materials Corporation (MEMC), they started the first commercial production, staking the United States as the initial, singular and dominant player in the fledgling silicon wafer industry. Although the United States started and developed the semiconductor silicon wafer industry, in the 1970s, Japanese companies, then considered two decades behind in technology, began to flourish and eventually came to dominate the field by 1985. In 1980, half of all silicon products came from the United States and only 25% in Japan. By 1985, it was the other way around. Market forces led MEMC to open a new plant in Malaysia in 1970. The next offshore move came when it established production facilities in Japan in 1986, an example of a rare case of United States owned company manufacturing technical products within Japan.²¹

One significant contribution of the wafer to improvement was increasing the wafer diameter. This dramatically increases production and lowers per unit cost in parallel with the fact that every doubling of diameter quadruples the area available to make chips. Although again, the chip size remained relatively constant over the years, wafers have increased from the original 19mm diameter in 1959 to the state-of-the-art 450mm diameters of today. MEMC remained a pioneer in the field and was the first to produce 100mm wafers in 1975, 125mm wafers in 1979, 150mm wafers in 1981 and 200mm wafers in 1984.²²

Eventually Japanese giant Shin-Etsu Handotai (SEH) entered the market in 1967 and steadily gained market share. Germany added another chemical behemoth known as Wacker into the market in 1978. During the same period, a few other major Japanese companies, like Mitsubishi and Sumitomo, started producing wafers. By the mid 1980s, chip producers like IBM, Texas Instruments and Motorola were still producing their own wafers, but their production capacities were just a fraction of their total needs and they increasingly outsourced production to the wafer behemoths and subject market experts. For most of the 80s until the end of the 90s, the world market was relatively equally divided between Japanese, U.S. and German production. The largest five, SEH, Wacker, MEMC, Mitsubishi and Sumitomo held 80% of the world market by 2002.²³ SEH of Japan was clearly the market share leader of the world, while Wacker of Germany and MEMC of the U.S. competed for second place. Eventually, Mitsubishi and Sumitomo merged making them the second largest producer. The United States officially left the market place in 1989 when MEMC held 23% of the world market and was the nation's only producer of 200mm or 8 inch wafers. Under intense competition, MEMC was losing money and Monsanto found a buyer in a German conglomerate. Huls AG purchased MEMC in 1989 after congressional approval. The Department of Defense raised national security concerns with the potential loss of U.S. strategic capacity and the Committee on Foreign Investment in the United States (CFIUS) scrutinized the sale. Under the 1988 Omnibus Trade Act, the President could block a sale to a foreign company if National Security was at risk. On February 7, 1989, President George H.W. Bush announced his approval for the sale.²⁴

Essentially from this point on in 1989, nearly all silicon wafers, which effectively means nearly all electronic products, were technically made on wafers produced by foreign-owned companies, Japanese and German primarily. Nonetheless, a fair amount of U.S. based but

foreign owned wafer production remained in the U.S., as was the case with MEMC. The 1990s saw continued competition and globalization pressures on the wafer manufacturing industry. There were large expansions by MEMC in Taiwan to support what became the largest chip producer in the world, Taiwan Semiconductor Manufacturing who eclipsed Intel, and in Korea to support electronic giants like Samsung. MEMC's German owners also expanded production in the United States, specifically targeting Intel's chip business and Texas Instruments' electronics market through a Joint Venture, with provisions to produce nearly all Texas Instruments' wafer requirements. At the same time, MEMC built other new facilities through Joint Ventures with Samsung and the Korean government in Korea and Taiwan Semiconductor Manufacturing Company and the Taiwanese government in Taiwan. MEMC continued expanding production in other cheap labor markets like Malaysia. With these expansions in the 1990s, foreign production dwarfed U.S. capacity. An MEMC Joint Venture with the Peoples Republic of China eventually fell through after the industry meltdown of 2001.²⁵

The now German owned MEMC retained its headquarters in the U.S., but came under increasing pressure from global competition through the dot-com bust era. Eventually, MEMC hemorrhaged, but in a twist of fate, MEMC returned to U.S.-based ownership. In 2001, the company found itself over \$1 Billion in debt to its German owner who wanted to unload MEMC. Initially unable to find a buyer, they offloaded the company to Texas Pacific Group for a symbolic \$1 per manufacturing plant and assumed \$200 Million of the debt if the failing company could return to profitability. Turning around failed businesses was Texas Pacific Group's forte and the company was eventually successful in turning MEMC around and divesting its interests, leaving MEMC as an independently operating U.S. company.²⁶ However, competition combined with the financial shocks near the end of the last decade took its toll. In

2009, MEMC announced they would close all U.S. based manufacturing of silicon wafers. Therefore, although a United States owned company technically reentered the silicon wafer market in 2001, they like many industries eventually elected to move all manufacturing overseas. This is the current state of affairs. The United States is now in a position where nearly all electronic components, including those for the national defense industry, are dependent on foreign production since the only major U.S. based producer elected to move all manufacturing production of wafers overseas.

The semiconductor and electronics industries will likely remain the key industries driving advances in defense weapons systems. The only U.S. tier one producer has plotted a course to outsource all manufacturing infrastructure and production. For most defense industries, this situation would be less than desirable, but not a potential strategic liability. To concede the control of all electronic device production to even our staunchest allies would seem ill advised. Yet the state of industry today is that only wafers made in Japan, Korea, or Taiwan and from some U.S. based facilities that are Japanese and German owned are capable of producing the most advanced defense electronic products. Although it might be intuitive from Moore's Law, it bears emphasizing that this industry changes rapidly to bring about the rapid improvements in the electrical devices discussed earlier. This also requires huge investments in capital equipment as well as research and development that would escape and be difficult to replace. Silicon wafers are made, grown actually, to meet the specific requirements of the computer chip (device) built on them. The proprietary, incremental and rapid nature of the evolution of wafer production to support new products or device features would make it very difficult if not impossible to reenter wafer production for electronic devices without reengineering the devices or an extraordinary technical effort devoted to transfer the technology. Such a hypothetical

transfer of intellectual property between global market competitors would be highly unlikely. Securing our defense electronics industry is one place where we are decidedly at risk due to an apparent failure to recognize the need to retain United States based silicon wafer manufacturing production.

The unchecked losses within the semi-conductor electronics industry are illustrative of other key defense industry losses. Some critical gaps gained exposure during efforts to support the fight in Iraq and Afghanistan. For example, after the Defense Department determined there was an urgent need to increase the armor protection on vehicles for our forces in Iraq, it was discovered the only remaining United States based company capable of producing steel of sufficient strength and quality was not only foreign owned but did not have the surge capacity to meet requirements.²⁷

Rare Earth Elements. The security of access to rare earth elements (REE) is another area of concern that receives a lot of attention. According to a 2010 Congressional Research Service report, there is no longer any rare earth mining production in the United States and, except for some minor recycling initiatives; we are almost 100% dependent on imports and strategic reserves. This is a case where the United States was self reliant with ample resources, reportedly the third largest reserves, as well as existing infrastructure and a standing industry but elected to idle and abandon mining and production. This occurred at a time when demand for REE was skyrocketing. These decisions were primarily a function of environmental concerns and regulations that restricted and discouraged mining operations, economic profitability of low yielding geological reserves and, again, global competition. In 2009, China produced 97% of global REE production, but by 2012, they expect to consume all their domestic production internally. In July 2010, China created alarm by announcing they would cut exports by 72% for

the second half of the year. The CRS report concludes that even with increases in domestic mining, China or other foreign countries would still be required for downstream processing and manufacturing. Their estimates show it could take up to ten years to restore some REE production. Critical defense products that require REE include: Engines, missile and precision guidance systems, antimissile defense systems, lasers, radar systems, electronic counter measures, optical components, smart bombs, underwater mine detection systems, satellite power and communications systems, aircraft engines and multiple aircraft components. Commercial and dual use items include catalytic converters, hybrid and electric vehicles, phosphors for colors in displays, permanent magnets, rechargeable batteries, wind turbine generators, lasers, medical devices and steel alloys.

Figure 5: 2009 Rare Earth Element Production

| 2009 RARE EARTH ELEMENT PRODUCTION | | | | |
|------------------------------------|---------------------------|------------|-------------------------|------------|
| COUNTRY | Production Metric Tons | % of Total | Reserves Metric Tons | % of Total |
| United States | None | | 13.0 | 13% |
| CHINA | 120,000 | 97% | 36.0 | 36% |
| Russia & former USSR | | | 19.0 | 19% |
| Australia | | | 5.4 | 5% |
| India | 2,700 | 2% | 3.1 | 3% |
| Brazil | 650 | | | |
| Malaysia | 380 | | | |
| Other | 270 | | 22.0 | 22% |
| TOTAL | 124,000 | | 99.0 | 100% |

In summary, our dependence on imports and the global scarcity and competition for REEs is shaping up to be a near term impending National Security Crises.²⁸

In 2008, the Department of Defense Strategic Materials Policy Board provided definitions for strategic and critical materials that led to some concern and controversy. Strategic materials are by this definition “essential for important defense systems” and “unique in the function it performs,” and there are “no viable material alternatives available.” Critical materials are strategic materials that must also meet the following three criteria: “1) the Department of Defense dominates the market for the material, 2) the Department’s full and active support are necessary to sustain and shape the strategic direction of the market, and 3) there is significant and unacceptable risk of supply disruption due to vulnerable U.S. or qualified non-U.S. suppliers.”²⁹

While considered strategic, the Board did not classify REE as critical materials, which by regulation would require action to shore up reliable access. Reduced domestic production and competition for resources through rapidly increasing worldwide demands have created shortages and delays in defense production. With these restrictive qualifiers, designation as a critical material is essential to secure a domestic supply and to date only beryllium, not an REE, was determined to be a critical material and the only example where authority was exercised to intervene.³⁰ Several materials, to include REE, have caused production delays in defense weapons systems and prompted a flurry of activity discussed below.

Congress took several actions to address access to REE. House Bill H.R. 6160 Rare Earth and Critical Materials Revitalization Act of 2010 establishes R&D programs within DOE to enhance mining production and improve value added downstream processing as well as improve recycling efforts and conduct research for possible substitutes. Program funding would provide loans to commercial initiatives to enhance mining, refining and production of critical RRE products. This bill never became law.³¹

H.R. 4866, the Rare Earths Supply-Chain Technology and Resources Transformation Act of 2010 proposes to: “To reestablish a competitive domestic rare earths minerals production industry; a domestic rare earth processing, refining, purification, and metals production industry; a domestic rare earth metals alloying industry; and a domestic rare earth based magnet production industry and supply chain in the United States.”³² This bill formalizes responsibility for examining the supply chain; identifying critical REE; acquiring, processing, and stockpiling required reserves as part of the National Defense Stockpile. Loans would be available to reestablish domestic supply chains to supply REE for defense needs. The Senate introduced companion bill, S. 3521; Rare Earths Supply Technology and Resources Transformation Act of 2010, but neither act became law.

H.R. 5136, The Fiscal Year 2011 National Defense Authorization Act would require the Secretary of Defense to determine if any REE materials were strategic or critical to national security to National Security. Readdressing the earlier definitions of the Strategic Materials Protection Board, this act required in either case, if REE were determined to be strategic or critical, the Secretary had to establish a plan to ensure long-term access. This act also addressed the urgent need to restore domestic production of sintered neodymium iron boron magnets, a REE for defense applications. This act also failed to become law.³³

The Fiscal Year 2010 National Defense Authorization Act, which became law, required the Comptroller General to establish which weapons systems require REE, which ones require foreign sources and the reliability of these supply chains. It also requires the Department of Defense to do the same and also to project future needs and disclose past actions or plans to minimize potential risks.³⁴

The National Defense Stockpile. The National Defense Stockpile, originally established in 1939, provided a means to ensure the ready availability of strategic and critical materials and reduce dependencies on foreign sources in the event of a national emergency. After the Cold War, Congress determined 99% of the materials were in excess and authorized their sale and disposal. By the end of Fiscal Year 2006, over \$6.4 billion in sales accumulated and only \$1.22 billion in inventory remained.³⁵

At this time recognized shortages and delays in materials to support the wars in Iraq and Afghanistan spurred congress to curtail the program and direct Department of Defense to readdress stockpile requirements. Initial results determined the stockpile needed reconfiguring to respond to changes in the marketplace and there was insufficient information on domestic capacity and the ability to forecast future requirements. The Defense National Stockpile Center contracted with National Research Council for further study and they published a report entitled *Managing Materials for a 21st Century Military*. In response, the Department of Defense established a Strategic and Critical Materials Working Group as part of the Strategic Materials Protection Board (SMPB). The Department of Defense established the SMPB pursuant to the National Defense Authorization Act of 2007 in reaction to the alarm raised over defense disruptions. In their April 2009 *Reconfiguration of the National Defense Stockpile Report to Congress*, the Working Group confirmed the need to revamp the stockpile system into a Strategic Materials Security Program (SMSP) and to revise current disposal policy. The Working Group also took on the challenge of trying to create a robust system and process to maintain visibility on the dynamic and evolutionary changes to critical materials requirements. To do this they contracted Institute for Defense Analysis (IDA) to assess the risk to continuous supply from a list of selected materials. In summary the report identified 13 materials (see Table 2) to suspend or restrict sales where the U.S. was “largely import dependent, for which no viable economic

substitute exists, or for which there is concern over the source (for geopolitical reasons) or the supply (for market reasons).” They also identified another 39 materials that should be “monitored, studied and/or considered for future mitigation strategies to ensure availability.”³⁶

Table 2. Stockpile Materials where Sales were Suspended or Restricted.

| COMMODITY | DEFENSE USE | COUNTRIES OF ORIGIN | REMAINING INVENTORY | % IMPORT DEPENDENCE |
|---|--|---|--|---------------------|
| Zinc | Galvanizing agent for steel | Canada, Peru, Mexico, Australia | 8,264 Short Tons | 58 |
| Tin | Anti-corrosive, alloying agent | Peru, Bolivia, China, Indonesia | 3,863 Metric Tons | 79 |
| Iridium | Hardening agent in platinum alloys | South Africa, United Kingdom, Germany, Canada | 567 Troy Ounces | 94 |
| Platinum | Catalyst; heavy-duty electrical contacts | South Africa, United Kingdom, Germany, Canada | 8,380 Troy Ounces | 94 |
| Germanium | Semiconductors and transistors, fiber optics, medical industry | Belgium, Canada, Germany, China | 17,871 Kilograms | 100 |
| FerroChrome (High Carbon and Low Carbon) | Stainless steel | China, Africa, Kazakhstan | 314,847 Short Tons | 62* |
| Tungsten Metal Powder and Tungsten Ores and Concentrate (O & C) | Steel hardening and toughening | China, Canada, Germany, Portugal | Powder - 585,619 Pounds; O&C – 46 million Pounds | 70* |
| Tantalum Carbide | Hard refractory ceramic | Australia, Brazil, China, Germany | 3,801 Pounds | 100 |
| Niobium/Columbium | Nuclear industry, superconductor | Brazil, Canada, Estonia, Germany | 22,156 Pounds | 100 |
| Cobalt | Magnetic properties, corrosion and wear resistant | Norway, Russia, Finland, China | 2.26 million Pounds | 78* |
| Ferromanganese | Used in steel production and steel deoxidizer | South Africa, Belgium, Ukraine | 526,000 Short Tons | 100 |
| Beryllium | Aerospace systems and nuclear weapons | Kazakhstan, Germany, United Kingdom | 215 Short Tons | 100 |
| Chromium Metal | Aerospace systems and high grade stainless steel | South Africa, Kazakhstan, Russia, Zimbabwe | 5,390 Short Tons | 62* |
| * Indicates where secondary material sources are included—not all such material is suited for defense purposes. Import dependency is therefore much higher for these materials. | | | | |

The IDA found that 22 of the materials assessed for risk from an Office of the Secretary of Defense Survey had already caused some kind of significant weapons system production delay. In addition, the IDA pointed out that an additional 19 materials from the survey list, which were not included in the risk assessment, were involved with some kind of defense production delay. Although no REE were included in IDAs risk assessment, three of the additional 19 were REE.³⁷

Input from a United States Geological Survey report listed another set of 19 minerals that the U.S. is 100% dependent upon Imports, concluding 12 were important to defense systems.³⁸

Insight from other Studies. In a September 2010 Congressional Research Service (CRS) report entitled *Rare Earth Elements: The Global Supply Chain*, they provide a listing of the relevant legislation used in the acquisition of defense systems. These include the Defense Production Act, the National Defense Stockpile, Buy American Act, Berry Amendment, and the Specialty Metals provision. It goes on to say these policies are in conflict about what is considered “‘critical’ [or] ‘strategic’ or necessary for national security and there is a certain lack of cohesion to the application of these policies.”³⁹ In summary, the Congressional Research Service concludes that REE are essential to national security, and that the United States lacks “presence” in the REE global supply chain and is highly vulnerable to supply disruptions with severe impacts.⁴⁰ In addition to the legislative acts already discussed, suggested policy options included: 1) United States Geological Survey Assessments to identify more “economically exploitable REE deposits” and conduct research for secondary recovery processes and identify material substitutes, 2) support increased exploration of REE outside of China, 3) challenge China on its export restrictions through the WTO and 4) establish stockpiles.

In a review of the tools available to the Department of Defense to manage critical materials, the Industrial College of the Armed Forces, in a 2010 Strategic Materials Industry Study, concludes that the former Specialty Metals Clause of the Berry Amendment, since revised into a separate United States Code, was the only program to target strategic materials.⁴¹

A latter CRS report from October 2010, *The Specialty Metal Provision and the Berry Amendment: Issues for Congress*, deals with some of the inconsistencies and problems. This CRS report highlights that in their first meeting in 2007, the Strategic Materials Protection Board created the following definition: “the term ‘materials critical to national security’ would be taken to mean ‘strategic materials critical to national security’ or simply ‘strategic materials’ and would include those specialty metals listed in 10 U.S.C. 2533b and any other materials the board chose to designate.”⁴² The report points out that this definition was abrogated during the 2008 meeting when the board modified these terms to require a “critical material” to be a strategic material that “1) the Department of Defense dominates the market for the material, 2) the Department’s full and active support are necessary to sustain and shape the strategic direction of the market, and 3) there is significant and unacceptable risk of supply disruption due to vulnerable U.S. or qualified non-U.S. suppliers.”⁴³ Through this definition mechanism, beryllium stood alone as the only material designated as “critical.”⁴⁴ Through this restrictive definition, the board reached the technical conclusion that specialty metals were not “materials critical to national security” concluding:

“In summary, the fact that specialty materials are essential for important defense systems does not mean that specialty metals are critical materials, nor that national security requires that only U.S. produced specialty metals be used for DoD applications.”⁴⁵

This finding was controversial and not well received by the metals industry and ergo some representative members of Congress. To add to the confusion, in July 2009, the Department of Defense implemented Section 804 of the 2008 National Defense Authorization Act requiring defense procurements to restrict all specialty metals to domestic sources only, with some exceptions like commercial off the shelf products. Clearly, the intent was to provide protection to the specialty metals industry and to safeguard domestic production capacity to meet defense requirements. Unfortunately, there were unintended consequences, not the least of which being that the United States does not, and could not, produce 100% of all defense requirements. Defense contractors in

many cases are unable to meet the tracking requirements and in some cases where it is feasible, it is not financially profitable to do so.⁴⁶

The Industrial College of the Armed Forces in their annual industry studies of the Manufacturing Industry consistently makes the case for its significance to national security and economic prosperity. Additionally, the reports call for corrective intervention with increasing foreboding of urgency for several years in a row. In the 2007 analysis, the report summarizes that the industry is “facing challenges that threaten its competitive advantage in the global market.”⁴⁷ The 2008 report chillingly stresses the point with the warning “these challenges to the sector, if left unaddressed, could erode America’s ability to maintain our way of life, influence its future and guarantee the national security.”⁴⁸ This report also felt the need to include a proposed letter to the incoming President on the challenges and suggested policy recommendations. The 2009 report sounds the alarm louder stating:

“The U.S. Manufacturing Industry is at a dangerous inflection point” and “now finds its leadership position threatened by global competition and adverse domestic behavior.” In addition, “analysis indicates trends in the global manufacturing ecosystem are leading U.S. manufacturing toward the wrong side of that inflection point. This report recommends the U.S. correct this divergence by adopting more supportive manufacturing policies reflective of both current global competition and U.S. needs. It further recommends these policies be based on comprehensive national economic strategy which incentivizes better collaboration between government, industry and academia.”⁴⁹

Finally, in 2010 the annual report explicitly reaches the conclusion there is a need for a National Manufacturing Strategy, emphasizing that:

“without concerted and coordinated focus on maintaining American competitiveness, however, our advanced manufacturing base, and future growth prospects will be eroded.” In summarizing, the report notes that “in a world of increasing complexity and uncertainty, the importance of continued sustainable economic growth to America’s security and prosperity cannot be over-emphasized” and the “the U.S. government can do more to improve America’s chances of success by adopting a concerted manufacturing strategy that compels policymakers and stakeholders to take a longer term view and help position American industry for the future.”⁵⁰

Manufacturing for the defense industry is a complex system with myriad material resource requirements and integrated technologies that are increasingly interdependent on global chains of material supplies and processes. This industry is increasingly difficult to monitor and manage in order to secure reliable access to resources. Constraints from scarcity, resource competition, economic competition and environmental restrictions make the problem dynamic and multifaceted. Nevertheless, because the stakes are so high the United States must look for ways and means to secure the minimum requirements of national security. In 2010, a National Manufacturing Strategy Act passed in the House of Representatives with bipartisan support on a vote of 379 in favor and 38 against. A Nationwide poll conducted in April 2010 of 1000 likely voters found overwhelming support across party lines for a National Manufacturing Strategy in answering the following question: “Some have proposed a national manufacturing strategy to make sure that the economic, tax, labor and trade policies in this country work together to help support manufacturing in the United States. Would you favor or oppose such a proposal?” 83% of Democrats, 74% of Republicans, 78% of Independents, and even 74% of Tea Party Supporters, and 81% of Tea Party Opponents responded in favor. Compared to other industries (health care, finance/banking, service, high tech, knowledge, real estate, services, media, other) respondents overwhelmingly identified the Manufacturing Industry as “most important in the overall strength of the American Economy.” In a separate question comparing the same industries again, manufacturing was again determined “most important for our National Security.” The loss of manufacturing ranked above concerns for dependence on foreign oil, health care costs, immigration, terrorism, and several other hot button issues. When queried why we need a National Manufacturing Strategy, 30% of respondents selected because “we are coming too dependent on foreign countries for manufactured goods, including parts for airplanes,

tanks, and missiles that are critical to our national security.” Another 21% selected “to protect a critical part of our national economy.”⁵¹

Conclusion. With so much agreement on the subject, it may seem counter intuitive that a National Manufacturing Strategy has not already materialized. However, given the current situation and complexities of the problem and possible solutions, it is not surprising. Regardless, the need for a coordinated, long term and cohesive strategy is undeniable. The need to establish a National Manufacturing Strategy that transcends politics, bureaucracies, commercial profits and nearsightedness is imperative, persistent and growing. Decisive and deliberate action is essential to securing the future for the Defense Industrial Base, National Security, Economic Prosperity and the American Way of Life.

Endnotes

¹ Fitzpatrick, John C., *Writings of George Washington*, 30:491, quoted in W. Cleon Skousen *The Five Thousand Year Leap, Twenty Eight Ideas That Changed the World*, (n.p.: Freeman Institute, 1982), 263.

² Smyth, Albert Henry, *Writings of Benjamin Franklin*, Vol 3, (New York, McMillan, 1905), 416 quoted in W. Cleon Skousen, *The Five Thousand Year Leap, Twenty Eight Ideas That Changed the World*, (n.p.: Freeman Institute, 1982), 294.

³ Alleged but unverified quote from Admiral Yamamoto in the Film Tora! Tora! Tora!

⁴ Annual Industrial Capabilities Report to Congress, May 2010, November 14, 2010, 1.

⁵ Dow Jones Industrial Average, http://en.wikipedia.org/wiki/Dow_Jones_Industrial_Average; 14 November 2010.

⁶ Dot-Com Bubble Timeline, <http://timelines.com/topics/dot-com-bubble>; 14 November 2010.

⁷ Ibid.

⁸ Stock Market History, <http://www.bullinvestors.com/stock-history>, 14 November 2010.

⁹ U.S. Foreclosure Activity Increases 75 Percent in 2007, Realty Trac, January 30, 2008, http://www.realtytrac.com/content/press_releases/us-forecluse-activity-increases-75-percent-in-2007-3604?acct=64847; 14 November 2010.

¹⁰ Foreclosure Activity Increases 81 Percent in 2008, Realty Trac, January 15 2009, http://www.realtytrac.com/content/press_releases/forecluse-activity-increases%20-81-percent-in-2008-4551?acct=64847; 14 November 2010.

¹¹ Weekly Economic and Financial Commentary, Wells Fargo Economic Research, September 17, 2010; http://en.wikipedia.org/wiki/subprime_mortgage_crises, 15 November 2010.

¹² Volcker, Paul, “The Time We Have is Growing Short” May 25 2010, <http://www.nybooks.com/articles/archives/2010/jun/24/time-we-have-growing-short/?pagination=false>; November 15, 2010; Warren Buffet, Testimony, Financial Crisis Inquiry Commission, June 2, 2010; “Subprime Mortgage Crisis,” http://en.wikipedia.org/wiki/Subprime_mortgage_crises, 15 November 2010.

¹³ Bureau of Labor Statistics; Loren Thompson, “Intelligence Committee Fears U.S. Manufacturing Decline,” *Forbes*, February 14, 2011.

-
- ¹⁴ Bureau of Labor Statistics; Experts Testify to Congress: Decline of Manufacturing Threatens National Security, <http://blogs.alternet.org/speakeasy/2010/09/23/experts-testify-to-congress-decline-of-manufacturing-threatens-national-security/>, 15 November 2010.
- ¹⁵ Ibid.
- ¹⁶ Jeff Faux, U.S. Congress, House, Committee on Oversight & Government Reform, Subcommittee on National Security, Made in the USA: Manufacturing Policy, the Defense Industrial Base, and U.S. National Security, 111th Cong., September 22, 2010.
- ¹⁷ Robert Baugh, Ibid.
- ¹⁸ Michael J. Carden, National Debt Poses Security Threat, Mullen Says, *Washington D.C. American Forces Press Service*, August 27, 2010.
- ¹⁹ Moore's Law, http://en.wikipedia.org/wiki/Moore's_law, 17 November 2010.
- ²⁰ "Scatterometry: Measuring Ever Smaller Chip Production," Science Daily, March 9, 2010.
- ²¹ Pat Swinger, *Building on the Past, Ready for the Future, A Fiftieth Anniversary Celebration of MEMC Electronic Materials, Inc.*, (Virginia Beach, Donning, 2009) 28-42.
- ²² Ibid. 30.
- ²³ Ibid. 68.
- ²⁴ Ibid. 45-50.
- ²⁵ Ibid. 49-70.
- ²⁶ Peter Beller, *Mr Sunshine*, Forbes Magazine, April 21, 2008, <http://www.forbes.com/forbes/2008/0421/074.html>, (Accessed 15 November 2010).
- ²⁷ Loren Thompson, "Intelligence Committee Fears U.S. Manufacturing Decline," Forbes, February 14, 2011.
- ²⁸ Marc Humphries, *Rare Earth Elements: The Global Supply Chain*, Congressional Research Service, September 30, 2010, 1-7.
- ²⁹ Office of the Under Secretary of Defense (Acquisition, Technology & Logistics) *Report of Meeting Department of Defense Strategic Materials Protection Board Held on December 12, 2008*, (December 12, 2008), 2.
- ³⁰ Ibid. 9.
- ³¹ Rare Earth and Critical Materials Revitalization Act of 2010, H.R. 6160, 111th Cong., 2nd sess. (September 29, 2010).
- ³² Rare Earths Supply-Chain Technology and Resources Transformation Act of 2010, H.R. 4866, 111th Cong., 2nd sess. (March 17, 2010).
- ³³ National Defense Authorization Act for Fiscal Year 2011, H.R. 5136, 111th Cong., 2nd sess. (June 28, 2010).
- ³⁴ *National Defense Authorization Act for Fiscal Year 2010*, Public Law 111-84, 111th Cong., 1st sess. (January 6, 2009).
- ³⁵ Department of Defense, *Strategic and Critical Materials Operations Report to Congress*, Fiscal Year 2009, 1-3.
- ³⁶ Department of Defense, *Reconfiguration of the National Defense Stockpile Report to Congress*, April 2009, 3-8.
- ³⁷ Institute for Defense Analysis, *Supplementary Risk Assessments*, September 3, 2008, Appendix C to the Reconfiguration of the National Defense Stockpile (NDS) Report to Congress, April 2009, C-3 – C4.
- ³⁸ United States Geological Survey, 2008 US Net Import Reliance for Selected Nonfuel Mineral Materials, 2007, *USGS Mineral Commodity Summaries Table*, Appendix D to the Reconfiguration of the National Defense Stockpile (NDS) Report to Congress, April 2009, D-1.
- ³⁹ Marc Humphries, *Rare Earth Elements: The Global Supply Chain*, Congressional Research Service, (September 30, 2010), 6.
- ⁴⁰ Ibid. 1, 9, 15.
- ⁴¹ Industrial College of the Armed Forces, Final Report: Strategic Materials Industry, Spring 2010, (Washington D.C: National Defense University, Spring 2010), 10.
- ⁴² Valerie Grasso, Specialty Metal Provision and the Berry Amendment: Issues for Congress, Congressional Research Service, (October 5, 2010), 4.

⁴³ Office of the Under Secretary of Defense (Acquisition, Technology & Logistics) *Report of Meeting Department of Defense Strategic Materials Protection Board Held on December 12, 2008*, (December 12, 2008), 2.

⁴⁴ *Ibid.* 5.

⁴⁵ *Ibid.* App. 1, 9.

⁴⁶ Valerie Grasso, Specialty Metal Provision and the Berry Amendment: Issues for Congress, Congressional Research Service, (October 5, 2010), Summary, 6.

⁴⁷ Industrial College of the Armed Forces, Final Report: Strategic Materials Industry, Spring 2007, (Washington D.C: National Defense University, Spring 2007), i.

⁴⁸ Industrial College of the Armed Forces, Final Report: Strategic Materials Industry, Spring 2008, (Washington D.C: National Defense University, Spring 2008), 2.

⁴⁹ Industrial College of the Armed Forces, Final Report: Strategic Materials Industry, Spring 2009, (Washington D.C: National Defense University, Spring 2009), 2.

⁵⁰ Industrial College of the Armed Forces, Final Report: Strategic Materials Industry, Spring 2010, (Washington D.C: National Defense University, Spring 2010), 1, 22.

⁵¹ Mark Mellman & Whit Ayres, Alliance for American Manufacturing 2010 Survey of Likely Voters on Manufacturing and America's Global Economic Standing, <http://www.americanmanufacturing.org/content/aam-national-economic-poll>, 17 February 2011.